

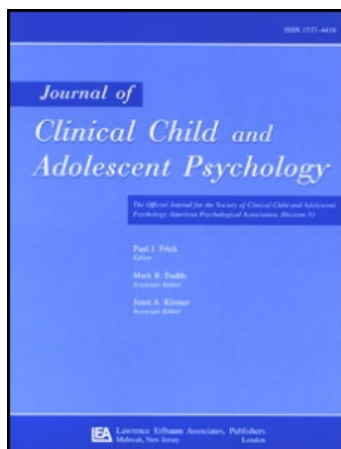
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### Patterns of Psychopathology in Children with ADHD: A Latent Profile Analysis

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# Patterns of Psychopathology in Children with ADHD: A Latent Profile Analysis

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This study used latent profile modeling (LPA) with a community sample that included an enriched sampling of children (aged 6–11) diagnosed with attention deficit/hyperactivity disorder (ADHD) ( $N=271$ ). Six classes of ADHD emerged from our LPA; only 17% of children fell into a class without significant co-occurring symptoms. In addition, nearly half of children were assigned to classes that could not be reliably distinguished using existing *DSM-IV* subtypes. For the most part, each of the classes was clearly differentiated from a sample of community controls and had clinical diagnoses and child self-reports that were consistent with expectations given by their latent profile of symptoms. Although each of the respective classes of ADHD had elevated levels of hyperactivity and/or attention problems, the current findings suggest that an exclusive reliance on these dimensions is a largely inadequate method of subtype classification. To the contrary, our findings suggest that ADHD subtypes can be more reliably partitioned based on the degree to which they display disruptive behavior, internalizing symptoms, or both.

The behavioral referents that characterize attention deficit/hyperactivity disorder (ADHD; American Psychiatric Association, 2000) reflect the latest attempt to harness an elusive concept. Indeed, no other psychiatric

disorder has undergone more conceptual, nosological, or definitional permutations (Lahey et al., 1988). For decades, questions have arisen concerning which behaviors or symptoms should define the construct (Lahey et al., 1994; Power et al., 2001) and how adherence to criteria should be measured (Power et al., 2001). The study presented here contributes to this burgeoning literature by using latent profile analysis (LPA) to classify children diagnosed with ADHD based on a full range of psychopathology, thus,

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providing an empirical depiction of the way these children are naturally sorted.

The historical study of the clinical construct, now termed ADHD, can be characterized by some consistent themes. First, the disorder is often persistent in nature and tends to impact development beyond the childhood years (Fischer, Barkley, Fletcher, & Smallfish, 1993). Second, ADHD is associated with concurrent and future maladjustment across a range of areas (Carlson & Mann, 2002; Faraone, Biederman, Weber, & Russell, 1998; Moffitt, 1990; Ostrander, Weinfurt, Yarnold, & August, 1998). Third, the disorder tends to co-occur with a number of other psychiatric diagnoses in both clinic referred and epidemiological samples of children and adolescents (Angold, Costello, & Erkanli, 1999; Jensen, Martin, & Cantwell, 1997; Moffitt, 1990).

Factor-analytic studies utilizing both clinic-referred and epidemiological samples have reliably identified two factors: inattention and impulsivity/hyperactivity. Taken as a whole, these investigations have included different informants (e.g., parents, teachers), culturally diverse samples, both continuous and categorical data, and different types of rating scales and diagnostic interview protocols. Despite the methodological variance across studies, separate inattention and hyperactivity/impulsivity factors consistently emerge (Baumgaertel, Wolraich, & Dietrich, 1995; Brito, Pinto, & Lins, 1995; DuPaul, 1991; Holland, Gimpel, & Merrell, 1998). These factors are moderately correlated (Holland et al., 1998), yet they are treated as independent categories in the most recent diagnostic formulation (*Diagnostic and Statistical Manual of Mental Disorders* [4th ed.; *DSM-IV-TR*], American Psychiatric Association, 2000). These groupings of like behaviors serve as one of the core decision rules for ADHD inclusion. Individuals meeting the symptom threshold for inattention only, hyperactivity/impulsivity only, and both inattention and hyperactivity/impulsivity are diagnosed as ADHD Predominantly Inattentive, ADHD Predominantly Hyperactive/Impulsive Type, and ADHD Combined Type, respectively.

#### THE RELATIONSHIP BETWEEN ADHD AND OTHER FORMS OF PSYCHOPATHOLOGY

Validation studies have typically centered on the differences between the predominantly Inattentive and Combined forms of ADHD (Carlson & Mann, 2002; Faraone et al., 1998; Lahey et al., 1994; Neuman et al., 2001). Yet the importance of comorbidity in conceptualizing, evaluating, and treating children and adolescents diagnosed with ADHD cannot be overestimated. Children diagnosed with varying iterations of the ADHD

nosology have displayed a variety of internalizing and externalizing disorders. In community samples, the comorbidity between ADHD and conduct disorder/oppositional defiant disorder (CD/ODD) is very high (42–93%). Moderately high rates of comorbidity between ADHD and internalizing disorders (e.g., depression, anxiety) have also been reported (13–51%; Jensen et al., 1997).

The level of co-occurring psychopathology also appears to differ between the ADHD subtypes; however, the form of comorbidity associated with a particular subtype of ADHD often varies across studies (Eiraldi, Power, & Nezu, 1997; Gadow et al., 2004). Firm conclusions concerning the relationship between ADHD subtypes and comorbid conditions can be obscured by the failure to account for method variance (Angold, Costello, & Erkanli, 1999; Caron & Rutter, 1991; Crystal, Ostrander, Chen, & August, 2001; Gadow et al., 2004). Recent research has emerged that has controlled for many of these methodological confounds and has identified salient distinctions between the most common subtypes of ADHD (Crystal et al., 2001). Although depressive symptoms appear to be equally represented across the Inattentive and Combined subtypes of ADHD, the Combined Type of ADHD has a particularly strong relationship with CD and aggressive/delinquent behavior (Crystal et al., 2001). Moreover, when CD is comorbid with ADHD, the risk for future criminal offending and substance dependence exceeds the risk associated with a diagnosis of CD or ADHD alone (Lahey et al., 1988; Moffitt, 1990).

The high rate of comorbidity associated with ADHD begs the question: Are co-occurring symptoms truly instances of two or more distinct syndromes (e.g., ADHD and CD) or are they, in fact, defining features of ADHD subtypes? For example, some have proposed that a valid way of partitioning children with ADHD may be achieved by considering the degree to which externalizing or anxiety disorders are also present (Jensen et al., 1997; World Health Organization, 1993). Others have argued that a subset of children with the Predominantly Inattentive Type of ADHD also display symptoms of depression and anxiety and are better characterized as having a “sluggish cognitive tempo” (Carlson & Mann, 2002). Some have found that the severity of inattention/hyperactivity problems is a function, at least in part, of whether comorbid disorders are present (Biederman et al., 1993). Likewise, the various phenotypes associated with conduct and depressive disorders may differ when symptoms of inattention or hyperactivity co-occur (Herman, Ostrander, Walkup, Silva, & Marsh, 2007; Thapar, Harrington, & McGuffin, 2001). Taken together, these findings would suggest that focusing exclusively on symptoms of inattention and/or hyperactivity–impulsivity

may provide inadequate coverage of essential qualities associated with ADHD. As pointed out by Ruscio and Ruscio (2004), relying on a set of indicators that are overly restrictive can lead to inaccurate conclusions concerning the underlying structure of a psychopathological construct.

Expanding the indicators of ADHD to reflect other dimensions of psychopathology may help clarify the underlying structure of ADHD and may help to reconcile conflicting findings derived from past research. At the same time, greater nosological accuracy is a necessary element when addressing research efforts concerning phenomenology, etiology, and treatment (Biederman et al., 1992; Meehl, 2001; Ruscio & Ruscio, 2004).

### THE UNDERLYING STRUCTURE OF ADHD: TOP-DOWN AND BOTTOM-UP APPROACHES

For the most part, studies that have examined the relationship between ADHD and other forms of psychopathology have been predicated on the diagnostic criteria set forth in the *DSM-IV* (4th ed.; *DSM-IV-TR*). The inherent assumption in this approach is that relatively homogeneous groupings of individuals are reliably identified based on specified decision rules and diagnostic criteria. In this manner, the empirical consensus that have been reached to date have been based largely on a top-down analysis of an artificially circumscribed collection of ADHD symptoms only. Recently, leaders in the field of psychology have argued for a more inclusive and nuanced view of psychopathology and approaches to research methodology/statistical operations (Barlow, 2005).

Latent profile modeling, a variation of cluster analysis, offers a more inclusive and bottom-up approach to devising nosological constructs. In this approach, classes of youth are identified that are somewhat independent of diagnostic rules, personal biases, and theoretical allegiances. Through the use of empirical decision rules, categories are formed based on how individual symptom patterns naturally occur. Thus, latent class analysis (LCA) determines the relative probability that an individual will be assigned to a group (or cluster) based on a defined set of behavioral referents.

A number of recent studies have used LCA to create a bottom-up approach to characterize the underlying structure of ADHD; however, these studies have typically relied on a very restrictive sampling of behavioral referents and have focused exclusively on the symptoms of ADHD that are listed in *DSM-IV* (e.g., Volk, Neuman, & Todd, 2005). Given the reliance on a restricted range of symptoms, it is not surprising that these studies have identified clusters of children that have either

mild or severe variants of the inattentive, combined, and hyperactive subtypes that are depicted in the *DSM-IV* (Neuman et al., 2005). On the surface, these studies would appear to validate the basic nosology depicted in the *DSM-IV-TR* (American Psychiatric Association, 2000). However, a more accurate classification may be obtained by considering all the relevant indicators that could denote the respective variants of ADHD (Ruscio & Ruscio, 2004).

Only one study that has examined the underlying the latent structure of ADHD while including co-occurring forms of psychopathology (i.e., Neuman et al., 2001). This study involved a very restrictive sample and was confined to a community sample of adolescent female twins. The LCA yielded three distinct and highly heritable classes of ADHD. In two classes, high levels of inattention were prominent, and these classes were distinguished primarily by whether oppositional behaviors were also present. A third class displayed uniformly high levels of inattention and hyperactivity in conjunction with elevated rates of oppositionality, anxiety, and depression (Neuman et al., 2001). Because girls are typically underrepresented in samples of ADHD children and hyperactive/inattentive symptoms diminish during the course of adolescence (Loeber & Keenan, 1994), findings derived from this study apply to a small subset of individuals who are diagnosed with ADHD. Moreover, the apparent comorbidity found in this study may be an artifact of nosological considerations inherent with a reliance on *DSM-IV-TR* criteria (Caron & Rutter, 1991). For example, the *DSM-IV-TR* imposes a dichotomous structure even when most psychopathology is better viewed dimensionally (Fergusson & Horwood, 1995; Levy, Hay, McStephen, Wood, & Waldman, 1997; Meehl, 2001). Likewise, apparent comorbidity may reflect the cross loading of symptoms across the ostensibly discrete *DSM* diagnostic categories (Pillow, Pelham, Hoza, Molina-Brooke, & Stultz, 1998). Despite these clear limitations, the findings provide tentative support for the notion that the underlying structure of ADHD is determined by the extent of overlapping psychopathology (Neuman et al., 2001).

The purpose of this study is to use a bottom-up approach to examine the underlying structure of ADHD. Using latent profile modeling, we examined the underlying structure of ADHD based on common dimensional referents of the disorder (i.e., attention problems and hyperactivity-impulsivity) while including related aspects of psychopathology (i.e., anxiety, depression, conduct problems, aggression). In this manner, we identified discrete subsets of ADHD in a manner that is not influenced by historical precedents, existing paradigms, or diagnostic boundaries (Todd, 2000). By focusing on a community-derived sample and relying on dimensional measures of discrete forms

of psychopathology, our study also addresses limitations that are commonly associated with studies that have examined comorbidity (Caron & Rutter, 1991). After specifying the latent classes, we determined the clinical significance of these classes by examining whether the respective classes can be reliably distinguished from a nonclinical sample. Finally, we examined how reliably the respective groupings of children with ADHD correspond to prevailing diagnostic categories and other indices of psychopathology.

## METHOD

### Participants

A community population of 7,231 children, initially in Grades 1 to 4, attending 22 schools, was screened using a sequential, two-stage assessment strategy (see August, Realmuto, Crosby, & MacDonald, 1995, for a detailed description). The Research protocol was approved by the Institutional Research Review Board Committee on Human Subjects at the University of Minnesota. Parents from the entire school population were required to provide consent for their child to participate in the initial screening and identification phase. As part of the initial consent, parents were informed of the classroom-wide assessment procedure and asked to consent for their child's participation. Based on parent and teacher ratings, each exceeding 1.75 *SD* units above the mean on the 10-item Hyperactivity Index (HI) of the Revised Conners Rating Scales (Goyette, Conners, & Ulrich, 1978), 309 (4.3%) children were screened positive and exhibited high levels of problematic behavior across settings.

A comparison sample of children, not rated as problematic by either parent or teacher, was also identified. All negative screens were included as potential community controls ( $n = 6,589$ ). Final selection of non-ADHD community controls was determined by the following criteria. Ten percent of students scoring less than 1 *SD* above the mean on both the parent and teacher versions of the HI were randomly selected and were further stratified to match the proportional representation of the participants with ADHD according to school, grade, and gender (August et al., 1995). Control participants were ultimately identified if they also reported no history of psychotropic medication use and had no prior history of clinical assessment for behavioral problems. There were 144 participants that were originally identified as community controls; however, 130 agreed to participate in the study and completed at least some of the assessment tools. Most nonresponders were lost because of reassignment to another school district or because they moved from their original school district.

After the screening process, the sample consisted of 309 problem and 144 nonproblem children ( $N = 453$ ), ranging in age from 6.6 to 11.75 years. The sample was 79% boys, 95% Caucasian, and predominantly middle class, although all socioeconomic levels, as determined by the Hollingshead (1975) index, were represented.

### Diagnostic Procedures

Several months after the screening, parents completed mailed questionnaires and teachers completed questionnaires distributed in the schools. At the same time, child psychiatric diagnoses were generated through use of the Diagnostic Interview for Children and Adolescents-Revised-Parent Version (DICA-R-P; Reich, Shayla, & Taibelson, 1992). During the interval between screening and selection, one school district's catchment area was redrawn and some students were assigned to a new school district that did not participate in the study. Reassignment to a nonparticipating school district was the primary reason that 75 positive screens were unable to be interviewed with the DICA-R-P. A comparison of the participants and nonparticipants found the groups to be indistinguishable on socioeconomic status, family size, single parent status, the ages of parents and children, and their scores on the respective parent and teacher HI screening measures. The DICA-R-P was administered to parents over the telephone by eight trained research assistants (see August et al., 1995, for additional details). Research assistants participated in an intensive training program that included video training and role-play. An independent rater who assessed 20% of each assistant's interviews was used to obtain interrater reliability. Interrater reliability for the *DSM-III-R* (American Psychiatric Association, 1987) diagnoses of ADHD was .97. Diagnostic interviews were not administered to comparison students. However, the mean scores on the parent and teacher screening measure (HI) were at floor levels. Thus, it is unlikely that any of these children would be diagnosed with psychiatric disorder.

### Selection Criteria for ADHD Children

Because the DICA-R-P is based on *DSM-III-R* criteria, it was necessary to modify the criteria for ADHD so as to maximize concordance with *DSM-IV-TR* diagnostic criteria. Creating this analog to the *DSM-IV-TR* criteria involved a method consistent with the approach we have reported elsewhere and has demonstrated excellent discriminant and convergent validity (Crystal et al., 2001; Ostrander et al., 1998). This procedure divided the ADHD sample into 43% combined and 50% inattentive subtypes; the predominantly hyperactive subtype represented only 6%. Interrater

reliability (kappa) for the reconstructed subtypes was .96 for the inattentive and hyperactive-impulsive subtypes and 1.00 for the combined subtype. At the end of the identification process, the sample of children with ADHD consisted of 109 ADHD-Combined type, 123 ADHD-Inattentive type, and 16 ADHD-Hyperactive/Impulsive type ( $n=248$ ). The respective subtypes of ADHD did not differ in terms of age or gender distribution. Furthermore, a chi-square analysis of the parents' reports on the Hollingshead Index of Socioeconomic Status (Hollingshead, 1975) showed no significant difference among the groups in their overall distribution across Hollingshead's categories. Because of the relatively small numbers and the limited empirical support for the impulsive-hyperactive subtype (Neuman et al., 2005) these potential participants were not included in the study, resulting in a slight reduction in the ADHD sample ( $n=232$ ). The final sample included 232 children with ADHD and 130 community controls. Of these children, we obtained parent ratings from 163 ADHD children and 108 community controls.

#### Measures: Class Indicators

The Behavioral Assessment System for Children-Parent Rating Scale (BASC-PRS; Reynolds & Kamphaus, 1992) was used to provide a comprehensive coverage of the respective dimensions of psychopathology that have been associated with ADHD. The parents of the children participating in the study completed the BASC-PRS, which is comprised of 130 items rated on 4-point frequency scales ranging from 0 (*never*) to 3 (*always*). Relying on the parent report version of the BASC has several advantages over other assessment approaches. Of particular relevance, parent reports provide the most useful source of information when considering the full range of psychopathology (Kline & Douger, 2005; Loeber, Green, Lahey, & Stouthamer-Lober, 1989; Silverman & Ollendick, 2005). In contrast, the validity self and teacher reports is more limited and has particular relevance to the respective assessment of internalizing or externalizing problems (Auger, 2004; Loeber et al., 2004). Second, the item content associated with the clinical scales of the BASC-PRS was initially selected to conform to the most common diagnostic categories found in the *DSM-IV*. However, unlike the dichotomous and overlapping item content that is represented in the *DSM-IV-TR*, the item content of the BASC scales is nonoverlapping and item content was further refined through the use of structural equation modeling. As a result, the individual scales should coalesce only to the extent predicted from the correlations between the constructs underlying the scales (and not because of overlapping items or scale content that reflects an adjacent construct). The need for item purity is particularly important when examining

constructs that are expected to be highly related (i.e., hyperactivity-impulsivity and inattention; aggression and conduct problems; anxiety and depression).

The BASC manual reports good internal consistency ( $\alpha=.71-.91$ ) and test-retest reliability (.84-.92) for the BASC-PRS (Reynolds & Kamphaus, 1992). The BASC manual also reports compelling evidence concerning the convergent and discriminant validity of the parent rating scale (Reynolds & Kamphaus, 1992); furthermore, independent research using confirmatory factor analysis have supported the validity of the clinical scales (Blackman, Ostrander, & Herman, 2005; Crystal et al., 2001). Of note, high scores on the Attention Problems subscale are particularly effective at identifying children with ADHD; moreover, the hyperactive scale has been effective at discriminating between the Inattentive and Combined subtypes of ADHD (Crystal et al., 2001; Ostrander et al., 1998). The clinical scales of the BASC-PRS have also distinguished between ADHD children with and without comorbid externalizing or internalizing disorders (Blackman et al., 2005; Doyle, Ostrander, Skare, Crosby, & August, 1997).

#### Measures: Covariate Measures

**Child measures.** Because the results derived from the BASC-PRS relied on a single instrument that depended on parent reports, we also selected several covariate measures to provide a means of distinguishing between the respective classes using independent measures and raters. Because information provided by the child is particularly important when assessing internalizing problems, self-report measures of depression and anxiety symptoms were included.

The Child Depression Inventory (CDI; Kovacs, 1992) is the most widely used self-report measure of childhood depression. The CDI includes 27 items and is designed to assess the number and extent of depressive symptoms. The CDI has acceptable internal consistency and validity (Kovacs, 1992). Higher scores suggest greater depression. Although the CDI has good convergent validity, it has not reliably been able to discriminate between individuals diagnosed with depression and other forms of psychopathology (Kline & Douger, 2005).

The Revised Children's Manifest Anxiety Scale (RCMAS; Reynolds & Richmond, 1985) is the most commonly used self measure of anxiety. The RCMAS has 37 true-and-false items and has been found to have acceptable internal consistency and validity (Reynolds & Richmond, 1985). In particular, the Worry subscale score from the RCMAS effectively discriminates between outpatients with and without an anxiety disorder (Silverman & Ollendick, 2005). However, the RCMAS has not been able to reliably make the more

subtle distinctions when the comparison is between children diagnosed with an anxiety and affective disorder (Silverman & Ollendick, 2005).

**Structured interview.** The screening method that was described earlier included both parent and teacher reports; however, this screening process identified children that exhibiting a broad and undifferentiated range of psychopathology (August et al., 1995). To arrive at specific psychiatric diagnoses, the DICAR-P was administered to parents over the telephone by eight trained research assistants (see August et al., 1995, for additional details). The DICA diagnoses were grouped into the following categories for the class comparisons described later: ADHD subtype (Combined vs. Inattentive), disruptive behavioral disorder (CD or ODD), any anxiety disorder, and any depressive disorder (major depressive disorder or dysthymic disorder). An independent rater assessed 20% of each assistant's interviews. Interrater reliability for the respective DICA diagnoses ranged from .97 to 1.0.

### Statistical Methods

Our study used a person-centered latent variable approach (i.e., LPA) to classify children with ADHD into optimal grouping categories based on common symptom presentations (Nylund, Muthén, & Asparouhov, 2006). Rather than grouping similar items and variables as in factor analysis, person-centered analyses provide a way of grouping individuals into categories based on shared characteristics that distinguish members of one group from another group. Although cluster analysis has been the most commonly used person-centered method, it has several shortcomings including the lack a clear benchmarks or statistics for determining how well the solution fits the data. As such, the number of classes in cluster analysis is somewhat arbitrary.

LPA, on the other hand, enables researchers to identify discrete *latent* variables that best group individuals based on their scores from two or more discrete observed variables (McCutcheon, 1987). Traditional latent class approaches use categorical observed variables as indicator variables whereas the technique used in our study, LPA, uses continuous observed variables.

LPA is model based, that is, the model can be replicated with an independent sample (Nyland, 2006). In LPA, class assignment is determined through fit statistics and tests of significance. LPA assigns membership based on probabilities and thus is able to take uncertainty of membership, or error, into account; cluster analysis cannot. LPA is also more robust with regard to scaling differences on observed variables. LPA has outperformed cluster analyses in several Monte Carlo

studies. In addition, LPA affords the opportunity to include covariates and outcomes in models to determine how well specified groups compare to other indices of psychopathology (Walrath et al., 2004).

All analyses were conducted using MPlus 4.1 (L. Muthén & Muthén, 2004). As in structural equation modeling, with latent class models, there are multiple statistical indicators of model fit. In our analyses, more weight was given to the Bayesian Information Criterion (BIC; Schwartz, 1978) and the sample-size adjusted BIC (Sclove, 1987) because recent simulation studies suggest that the BIC provides the most reliable indicators of true model fit (Nylund, Muthén, & Asparouhov, 2006). In addition, we used a likelihood difference test—the Lo-Mendel-Rubin (2001), which assesses the fit between two nested models that differ by one class and provides a *p* value that indicates which model fits best. For example, a nonsignificant Lo-Mendel-Rubin *p* value for a four-class model indicates that the three-class model fits better than the four-class model. Finally, we used a recently developed Parametric Bootstrap Likelihood Validation Test (MPlus 4.1) to confirm the selection of the final class solution, testing whether the selected class model was significantly better than the solution with one fewer classes.

Entropy is also used as an indicator of how well the model classifies people, where values closer to or exactly 1 indicate better classification. However, entropy should always be examined in conjunction with other model fit indices. In subsequent analyses we conducted latent class regressions to determine if demographic, diagnostic, and functioning variables predicted class membership.

The Mplus software uses a full information maximum likelihood estimation under the assumption that the data are missing at random (Arbuckle, 1996; Little, 1995), which is a widely accepted way of handling missing data (Muthén & Shedden, 1999; Schafer & Graham, 2002). The covariance coverage for all variables ranged from 0.996 to 1.0, well above minimum thresholds for establishing adequate coverage (e.g., .10; Muthén & Muthén, 2004). The mixture missing command was used in all analyses to account for any missing data.

## RESULTS

### Identification and Description of the Latent Classes of ADHD

We first conducted an LPA with the ADHD participants only ( $n = 163$ ) to determine the optimal number of classes of ADHD and the clinical characteristics associated with each class. We included six indicators in these analyses: each child's *T* score on the BASC-PRS Anxiety, Depression, Conduct Problems, Aggression, Inattention, and Hyperactivity subscales. LPA fit

TABLE 1

Model Fit Indices for One- to Eight-Class Solutions of Parent Behavior Assessment System for Children Ratings Scores for Children Diagnosed with Attention Deficit/Hyperactivity Disorder

	<i>BIC</i>	<i>Adj. BIC</i>	<i>VLMR p</i>	<i>Adj. VLMR p</i>	<i>Entropy</i>
One-Class Solution	7656.52	7618.53	—	—	—
Two-Class Solution	7492.21	7432.06	.01	.01	.76
Three-Class Solution	7438.05	7355.73	.28	.29	.82
Four-Class Solution	7431.20	7326.72	.04	.04	.83
Five-Class Solution	7423.92	7297.29	.43	.44	.84
Six-Class Solution <sup>a,b</sup>	7415.67 <sup>a</sup>	7266.88	.13	.14	.85
Seven-Class Solution	7424.79	7253.83	.14	.15	.87
Eight-Class Solution	7437.38	7244.27	.22	.23	.89

Note. *N* = 163. All entropy ratings indicate acceptable fit. BIC = Bayesian Information Criterion; VLMR = The Vuong-Lo-Mendall-Rubin likelihood difference test.

<sup>a</sup>Best fit: Lowest BIC and adjusted BIC indicate better fit, and highest number of classes with lowest VLMR indicates best fit. <sup>b</sup>Parametric Bootstrap Likelihood Validation Test indicated that the six-class solution provided a superior fit versus the five-class solution ( $p < .0001$ ).

indices for one through eight class solutions are summarized in Table 1. The six-class solution yielded the lowest BIC value. A bootstrap validation procedure with 20 successful replications confirmed that the six-class solution offered a better fit than the five-class solution (log likelihood =  $-3851.4$ ,  $p < .001$ ).

Figure 1 summarizes the prevalence and clinical characteristics of the six identified latent classes. Class labels were assigned based on borderline clinical (*T* scores of 60 or higher) and clinically significant (*T* scores of 70 or higher) mean symptom scores for each class. Class 1 is best characterized as an Inattentive class (17%) given that none of the mean symptom indicators reached clinical significance for this class, and only one, inattention, reached the borderline clinical threshold. Class 2, the Internal Inattentive class (15%), was characterized by clinically significant levels of depression and moderate symptoms of inattention and anxiety. Class 3 was labeled Mild ADHD. It was the most common class (38%) and comprised moderate levels of inattention and hyperactivity (*T* scores 65–69). The primary distinction between Class 4 (17%) and Class 5 (4%) was the severity of their disruptive behaviors. Thus, these classes

were labeled Moderate Disruptive (Class 4) and Severe Mixed Pathology (Class 5). Both classes had clinically significant levels of all symptoms except anxiety. The *T* scores for Class 5 exceeded those for Class 4 on all symptom indicators by 10 or more points except the anxiety and inattention subscales. Finally, Class 6 (9%) resembled the Moderate Disruptive class in terms of severity of disruptive symptoms ratings but also had moderate symptoms of anxiety and clinically significant depression scores (a full standard deviation higher than the Moderate Disruptive Class). Given the presence of these internalizing symptoms, Class 6 was labeled Internal-Disruptive.

### Class Distinctiveness

We determined the distinctiveness of these classes by examining the respective pattern on a variety of covariate variables. As such, a series of statistical tests were employed to determine whether the respective classes could be distinguished by various demographic variables and clinical measures. Gender (boy or girl) and age (younger than 9 years vs. 9 and older) were entered as predictors of class membership to determine if these demographics distinguished among the groups. Although there were visual differences in class probabilities based on these characteristics, the only statistically significant differences were found for the Severe Mixed class. Children in this group were more likely to be older and female (odds ratio [OR] = 16.13; confidence interval [CI] = 1.12–250). In fact, all children in this class were 9 years or older and more than half were girls compared to the predominantly male composition of all other classes.

To determine if the respective classes could be reliably distinguished from a nonclinical population, we conducted two sets of analyses. First, we conducted a second LPA with the ADHD and community control

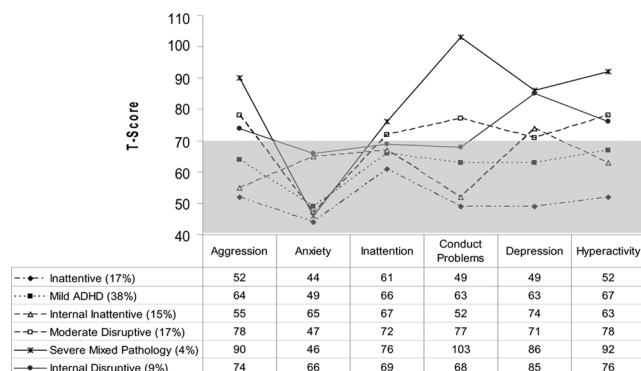


FIGURE 1 Clinical characteristics of classes.



participants ( $n=271$ ) to determine if the classes previously identified with ADHD participants only would be replicated when we added a seventh class for the community control group. The clinical characteristics associated with each of these classes were nearly identical to those previously described for the ADHD-only analyses with the addition of a seventh class that had mean  $T$  scores below 50 on all of the symptom indicators. We labeled this latter class the normal group.

In a second set of analyses we ran latent class regressions to determine the probability of each group (ADHD vs. community control) appearing in each of the seven classes. Figure 2 depicts these probabilities. The probability of being from the ADHD group was 1.0 for 4 of the classes (Mild ADHD, Moderate Disruptive, Severe Mixed Pathology, and Anxious-Disruptive) indicating that no community control participants were assigned to these classes (or rather, that their probability of being in these classes was zero). In addition, the probability of being from the ADHD group was .79 for the Internal-Inattentive class and .03 for the normal group. The only class with some ambiguity about their group of origin (ADHD vs. community control) was the Inattentive class. Although this class had a better chance of being from the ADHD vs. community control, the probability of being diagnosed with ADHD was more modest (.56) than was the case for all other classes of ADHD. Unlike all other classes of ADHD, this class had no  $T$  scores in the clinically significant range on the symptom indicators and only one in the borderline clinical range (Inattention). Therefore, it is not surprising

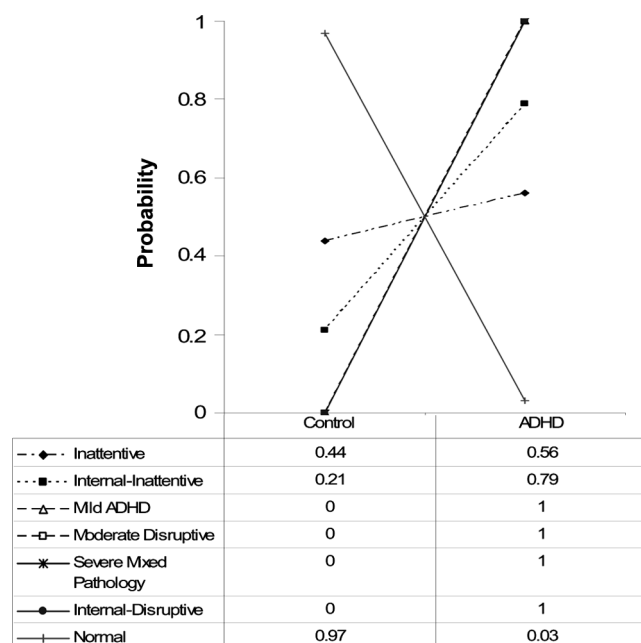


FIGURE 2 Probabilities of being from attention deficit/hyperactivity disorder or control group given class membership.

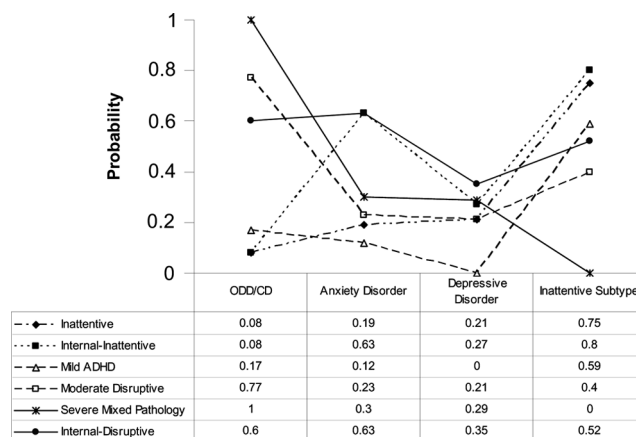


FIGURE 3 Probabilities of inattentive subtype, ODD/CD, anxiety disorder, or depressive disorder given class membership.

that children assigned to this class of ADHD were less distinct from the community control participants. Nevertheless, the probability of being from the ADHD group was significantly higher for both the Inattentive ( $OR=41.66$ ,  $CI=4.71-333.33$ ) and the Internal Inattentive ( $OR=125$ ,  $CI=11.63-1000$ ) classes compared to the Normal class. These findings suggest that these classes met criteria for establishing their distinctiveness.

We conducted additional latent class regressions to determine if *DSM-IV* diagnoses (any disruptive, anxiety, or depressive disorders) or ADHD subtypes (Combined vs. Inattentive) were associated with the class membership specified through LPA. Given that community control participants did not have clinical diagnoses, these analyses were conducted on the ADHD group only (the six-class solution).

Figure 3 depicts the probability of disorder and subtype given class membership. First, the figure illustrates the varied probability of having a disruptive behavior diagnosis and suggests that this diagnostic grouping finely distinguished the classes. The classes with the lowest probability of having a disruptive disorder, as expected, were the Inattentive and the Internal-Inattentive classes (both were .08); however, the Mild ADHD class also had a relatively low probability of having a disruptive behavioral disorder (.17). In comparison, the probability of Internal-Disruptive (.60) and Moderate Disruptive (.77) classes of having a disruptive disorder diagnosis was significantly higher than the Inattentive ( $OR=16.13$ ,  $CI=2.29-111.11$  and  $OR=45.45$ ,  $CI=5.59-333.33$ , respectively), Mild ADHD ( $OR=7.35$ ,  $CI=1.89-28.57$  and  $OR=16.67$ ,  $CI=3.92-71.43$ ), and Internal Inattentive ( $OR=16.67$ ,  $CI=1.28-200$  and  $OR=37.04$ ,  $CI=3.31-500$ ) classes. The Severe Mixed Pathology class had a probability of 1.0 of having a disruptive disorder diagnosis, meaning all children assigned to this class had been given a

disruptive behavior diagnosis. Class comparisons to the Severe Mixed Pathology class were precluded by the zero variance but these data still strongly support the distinctiveness of this class.

As determined through clinical interview, most of the classes had a relatively high probability of having a depressive disorder (major depression or dysthymia) given the young age range of the sample. The only exception to this trend was the Mild ADHD class; indeed, the zero probability of receiving a depressive diagnosis is evidence supporting its distinctiveness. The three classes that were characterized by clinically extreme elevations in the depression scale of the BASC also had the highest probability of being diagnosed with a major depression or dysthymic disorder: Internal-Disruptive (.35), Severe Mixed Pathology (.29), and Internal Inattentive (.27). Latent class regression analysis found that the visual differences depicted in Figure 4 were not statistically significant. However, it should be noted that the power for these analyses and all statistical comparisons among the classes was limited by the small sample size within each class.

Third, the presence of any anxiety disorder (vs. no anxiety diagnosis) was calculated. The two classes with the highest levels of anxiety on class indicators, Internal Inattentive and Internal-Disruptive, each had a .63 probability of having an anxiety disorder, more than twice as high as any other group. The Internal Inattentive and Internal-Disruptive classes had a significantly higher probability of having an anxiety disorder compared to the Inattentive (OR = 7.14, CI = 1.21–41.67 and OR = 7.30, CI = 1.59–33.33, respectively) and Mild ADHD (OR = 11.76, CI = 2.04–66.67 and OR = 12.05, CI = 2.68–55.56) classes. In addition, the Internal-Disruptive probability of anxiety disorder was significantly higher than the Moderate Disruptive class (OR = 5.88, CI = 1.01–1.02).

Finally, *DSM-IV* ADHD subtype distinguished several of the classes. Notably, the Severe Mixed Pathology class had a probability of 1.0 of having the Combined subtype. Statistical differences between the Severe Mixed Pathology class and all other classes could not be computed because of the zero variance in probability for this class. However, the 1.0 probability of having the Combined subtype for this class should be viewed as evidence supporting its distinctiveness. The Moderately Disruptive class also had a relatively high probability of having the Combined subtype of ADHD (.60). On the other hand, the Inattentive Only (.75) and Internal-Inattentive classes (.80) had greater probabilities of having the Inattentive subtype. Statistical comparisons among the groups indicated that there were significant differences in likelihood of having the Combined versus Inattentive subtypes when the Moderate Disruptive class was compared to the Inattentive (OR = 4.59,

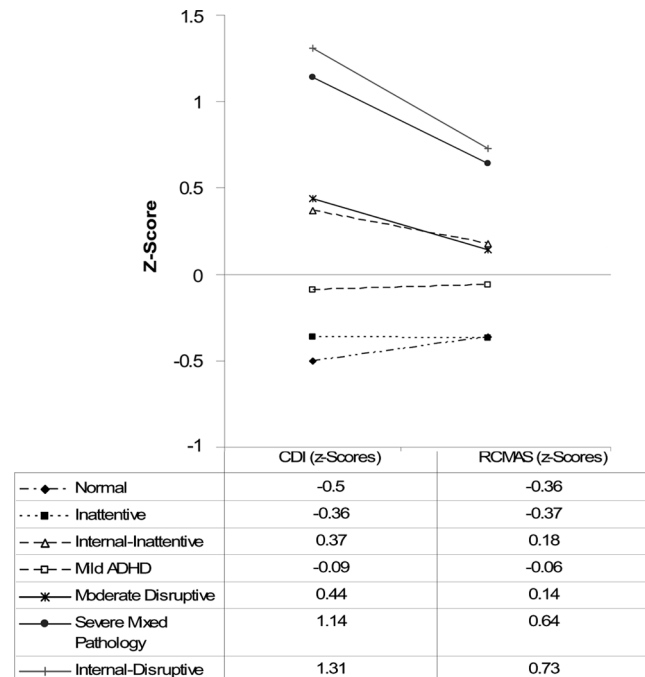


FIGURE 4 Children's Depression Inventory (CDI) and Revised Children's Manifest Anxiety Scale (RCMAS) estimated Z scores given class membership. Note: For CDI scores, Normal class was significantly lower than Internal Inattentive (Estimate = 1.061; Est./SE = 3.037), Mild ADHD (Est. = 0.644; Est./SE = 2.393), Moderate Disruptive (Est. = 1.110; Est./SE = 3.689), Severe Mixed (Est. = 1.499; Est./SE = 5.274), and Internal Disruptive (Est. = 1.570; Est./SE = 3.881). In addition, the Inattentive class was significantly lower than the Internal Inattentive (Est. = 0.793; Est./SE = 2.02), Moderate Disruptive (Est. = 0.842; Est./SE = 2.281), Severe Mixed (Est. = 1.231; Est./SE = 3.554), and Internal Disruptive (1.302; Est./SE = 2.979). In addition, the mild ADHD group was significantly lower than the Severe Mixed (Est. = 0.856; Est./SE = 2.519) and the Internal Disruptive classes (Est. = 0.927; Est./SE = 2.031). For RCMAS scores, Internal Disruptive was significantly greater than Normal (Est. = 0.846; Est./SE = 3.272), Inattentive (Est. = 0.851; Est./SE = 2.53), and Mild ADHD (Est. = -0.603; Est./SE = -2.106). Also, the Severe Mixed was significantly higher than Normal (Est. = 0.779; Est./SE = 2.253).

CI = 1.29–16.39) and Internal Inattentive classes (OR = 6.06, CI = 1.25–29.41). Of interest, the Mild ADHD and Internal-Disruptive classes could not be reliably distinguished from all other classes according to their respective probability of receiving a diagnosis of Combined (vs. Inattentive) subtypes of ADHD.

Comparisons were also made between classes and child-reports of internalizing symptoms on the CDI and the RCMAS. As depicted in Figure 4, CDI scores for each class varied from a sample-based z score of -.50 (Normal class) to 1.31 (Internal-Disruptive class). The mean z score for each class was generally consistent with class indicator characteristics. Classes with high internalizing symptoms and/or mixed severe symptom presentations scored above the sample mean on the CDI. Several of these visual class differences were also

statistically significant. For instance, the Normal class had a CDI score that was significantly lower than all other classes ( $p < .05$ ). The Inattentive class also had significantly lower mean scores than all other pathological classes except the Mild ADHD group ( $p < .05$ ). In addition, the Mild ADHD group was significantly lower than the Internal-Disruptive and Severe Disruptive classes ( $p < .05$ ; see Figure 4 for estimates).

The RCMAS Worry mean scores also resulted in a wide spread among the classes. The Internal-Disruptive, Severe Mixed, and Internal Inattentive classes have the highest mean scores on the Worry scale. Despite restrictions in power, there were also statically significant differences between the respective classes. Specifically, the Internal-Disruptive had significant higher mean scores on the Worry scale compared to Normal, Inattentive, and Mild ADHD classes ( $p < .05$ ). Also, the Severe Mixed Pathology Class had statistically higher mean RCMAS scores than the Normal classes ( $p < .05$ ; see Figure 4).

## DISCUSSION

Six classes of ADHD emerged from our LPA. Although each of the respective classes of ADHD had elevated levels of hyperactivity and/or attention problems, the current findings suggest that an exclusive reliance on these dimensions is a largely inadequate method of subtype classification. In particular, the Mild-ADHD and Internal-Disruptive classes could not be distinguished from other classes based on the *DSM-IV* subtype criteria. However, these classes represent nearly half (47%) of the total ADHD sample. In contrast, the respective classes of ADHD can be more reliably characterized based on the degree to which they display disruptive behavior, internalizing symptoms (particularly anxiety), or both. For instance, half of classes of ADHD (i.e., Moderate-Disruptive, Severe Mixed, and Internal-Disruptive) could be reliably distinguished by the extreme levels of broadly represented disruptive behaviors; in contrast, the remaining three classes (i.e., Inattentive-Only, Mild ADHD, Internal-Inattentive) were consistently found to display relatively mild levels of disruptive behavior. Among those classes with and without disruptive behaviors, the level of broad internalizing symptoms (particularly anxiety) tended to further separate the classes.

### Empirical Subtypes of ADHD

The findings from our study parallel prior research (Neuman et al., 2001) and would suggest that broadly represented disruptive behavior (with and without internalizing symptoms) represents a valid means of distinguishing among young people with ADHD. Although

prior research was restricted to adolescent girls and identified only three classes of ADHD (Neuman et al., 2001), our study would suggest that the partitioning of ADHD is more complex and multifaceted when a more representative sample of ADHD children is considered.

Our research would suggest that the Inattentive-Only and Mild-ADHD classes of ADHD appear to have a generally benign presentation and display few, or mild, symptoms of comorbidity. At the same time, multiple forms of psychopathology characterized the other classes of ADHD. Although several internalizing and externalizing symptoms were frequently displayed by the respective classes, in some instances, the manifestation of comorbidity was restricted to multiple internalizing symptoms. For example, high levels of anxiety and depression were associated with the Internal-Inattentive class. Of interest, others have also suggested that a distinct subtype of ADHD (i.e., sluggish cognitive tempo) might be characterized by high levels of inattention and internalizing symptoms without concomitant disruptive behaviors (Carlson & Mann, 2002). Recent research would suggest that a similar constellation of symptoms may also be characteristic of a discrete subset depressed individuals. For example, Herman and colleagues reported that a well-defined class of depressed adolescents has moderate inattention along with anxiety but few indications of hyperactivity (Herman et al., 2007).

Within the groupings that displayed broadly impaired disruptive behavior, the respective classes could also be further partitioned by whether the class displayed high or low levels of anxiety. For example, the BASC profile indicated that the Moderate Disruptive and Internal-Disruptive classes displayed uniformly elevated levels of disruptive behaviors and depression. However, the low levels of anxiety that characterized the Moderately Disruptive class were in notable contrast to the more extreme levels of anxiety displayed by the Internal-Disruptive group. It is noteworthy that Herman et al. (2007) also found similar classes of co-occurring symptoms in their sample of depressed youth. Empirically derived classes of depressed adolescents yielded one class of depressed adolescents that had broadly impaired attention in conjunction with disruptive behavior and extreme anxiety; at the same time, a separate class displayed marked inattention and extensive disruptive behaviors, yet, few symptoms of anxiety (Herman et al., 2007).

Although the classes of ADHD were reliably distinguished by the degree of anxiety and/or disruptive behavioral disorders, the BASC profile suggests that broadly represented internalizing symptoms offered a less discrete means of differentiating among the respective classes. Some of the classes displayed uniformly high levels of anxiety and depression (Internal-Disruptive, Internal-Inattentive); likewise, two of the

classes with low levels of anxiety also displayed very few indications of depression (i.e., Inattentive, Mild ADHD). Two other classes with low levels of anxiety displayed relatively high scale elevations on the depression scale of the BASC (i.e., Moderate Disruptive, Severe Mixed). These findings are consistent with emerging research showing that a large subset of children diagnosed with depression do not present with covarying anxiety and are more likely to be associated with high levels of inattention, disruptive behavior, or both (Herman et al., 2007).

The extreme overall clinical presentation displayed by the Severe-Mixed grouping of ADHD sets it apart from all other classes of ADHD. Of interest, the Severe-Mixed class displayed high point elevations on the BASC that is very similar to the profile of children diagnosed with pediatric bipolar disorder. Children with bipolar disorder have a clinical pattern on the Child Behavior Checklist that reflects extreme conduct problems, followed next in severity by Inattention/Hyperactivity, and then depression (Youngstrom et al., 2005). It is noteworthy that our study derived ambiguous findings concerning the presence of anxiety in this subset of children with ADHD. The Severe-Mixed class displayed few indications of anxiety on the BASC, and there was a similar trend on the DICA. However, a slightly different pattern was displayed on the self-report measure of anxiety. That is, the Severe-Mixed group was one of the few classes to display higher than normal elevations on the RCMAS; even so, the RCMAS was unable to distinguish the Severe-Mixed group from all other classes of ADHD. The limited discriminant validity of the RCMAS (Silverman & Ollendick, 2005) may have contributed to these ambiguous findings; however, it is also noteworthy that the level of anxiety associated with pediatric bipolar disorder has also yielded inconsistent results (Youngstrom et al., 2005). In any case, the role of anxiety in representing a distinguishing characteristic of the Severe-Mixed class will require further clarification.

### Explanations for the Co-Occurrence of ADHD and Other Forms of Psychopathology

There are a number of substantive explanations for the co-occurrence of psychopathology in children diagnosed with ADHD (Caron & Rutter, 1991). For example, the distinct symptom clusters observed in our study may simply reflect the high rate of diagnostic comorbidity associated with ADHD and other distinct forms of psychopathology. According to this perspective, the overlap of different forms of psychopathology reflects common risk factors. For example, both twin and family studies have suggested that ADHD and depression share a familial connection. However, it is unclear whether the

co-occurrence of these disorders is because of shared genetic or environmental influences (Burcusa, Iacono, & McGue, 2003; Faraone & Biederman, 1997).

A second perspective is that some of the classes represent distinct syndromes in their own right. For instance, Angold et al. (1999) pointed out that certain comorbid conditions might be different enough (in characteristics, associated features, etiology) to represent a distinct form of psychopathology. Rather than single comorbidities, however, our data would suggest that multiple symptom clusters are frequently represented in children with ADHD. The current *DSM-IV* nosology provides an inadequate basis for considering even singular comorbidities, let alone a clinical phenomenon involving multiple overlapping forms of psychopathology. The possibility that multiple comorbidities may represent a distinct clinical entity has recently received qualified support. For example, in adolescent girls, the latent classes of ADHD exhibiting multiple forms of comorbidity had a particularly strong genetic association (Neuman et al., 2001). If the respective classes do reflect distinct clinical entities, it would be important to understand the etiology of the respective clinical phenomenon (e.g., specific genetic influences) as well as the developmental outcomes associated with a particular class of psychopathology (Meehl, 2001). Our data were cross-sectional and thus provided only a snapshot of participants' symptoms at a single point in time. Future studies will need to model movement in and out of these classes over time. In addition, longitudinal studies may clarify whether academic, social, and vocational outcomes are differentially associated with the respective classes of ADHD.

Each of the identified classes may in fact reflect unique disorders, each with discrete developmental pathways. However, given the early developmental onset of ADHD, it is also possible that ADHD may represent a distinct risk factor that can contribute to other forms of psychopathology (Angold et al., 1999; Caron & Rutter, 1991). Indeed, our study would suggest that ADHD may lead to multiple outcomes, often termed "multifinality" (Cicchetti & Rogosch, 1996). Consistent with this notion, researchers have described a variety of pathways between ADHD, conduct problems, and internalizing disorders (Dishion, French, & Patterson, 2006; Herman & Ostrander, in press; Kovacs, 1992; Ostrander & Herman, 2006). For example, a recent line of research has noted that a variety of negative family, social, and academic experiences are engendered by children with ADHD. As development unfolds, these negative experiences contribute to harmful cognitions, which in turn lead to disturbances in mood (Herman & Ostrander, in press; Ostrander, Crystal, & August, 2006; Ostrander & Herman, 2006). Others have found that children with ADHD are more likely to elicit

ineffective responses from parents; overtime, a pattern of negative reinforcement emerges, which ultimately leads to escalating conduct problems (Dishion et al., 2006). The current findings suggest that these causal models may need further elaboration. At the very least, more complete models are needed in order to understand the mechanisms that contribute to the varied manifest symptoms that are associated with a diagnosis ADHD.

### Strengths and Limitations

In addition to the substantive considerations that may explain the co-occurrence of ADHD with other forms of psychopathology, there are also methodological considerations that may explain the apparently high prevalence of comorbidity (Caron & Rutter, 1991). For example, prior studies focusing on the type of comorbidity associated with ADHD have relied on clinical samples or depended on community samples that were not broadly representative of children with ADHD (e.g., Biederman et al., 1992, 1993; Neuman et al., 2001). By relying on a community sample, our study provided a representative sample of children with ADHD; in the process, this study also controlled for the inflated rates of comorbidity associated with clinic samples. Nevertheless, the sampling method used in this study did place some limitations on our findings. In particular, the population selected for the present study was predominantly Caucasian and middle class; in addition, we excluded children diagnosed with the Hyperactive-Impulsive subtype of ADHD from our analysis.

Our study used an optimal informant strategy (Holmbeck, Li, Schurman, Friedman, & Coakley, 2002). That is, we relied on parent reports on the BASC to provide valid indicators of the respective classes of ADHD. The validity of teacher and self-reports has been limited to the respective assessment of internalizing or externalizing disorders. In contrast, parent reports have been found to be more universally valid across a range of psychopathology (Kline & Douger, 2005; Pelham, Fabiano, & Massetti, 2005; Silverman & Ollendick, 2005). Although combining different methods and sources can provide a more comprehensive assessment of psychopathology, the approaches used to reconcile inconsistency between sources and measures may also inflate the estimates of comorbidity (Jensen et al., 1999; Youngstrom et al., 2005). Therefore, instead of combining information across different sources and instruments, we examined the relationship of the latent classes based on the BASC-PRS. The validity of this method was then determined by comparing the latent classes to other assessment methods that included independent instruments and/or respondents. Although this approach tended to support the validity of the latent

classes, future studies may wish to develop indicators of the respective latent classes that incorporate multiple sources and methods in way that will ensure a valid appraisal of psychopathology (Holmbeck et al., 2002).

Thus far, the only studies that have employed latent class approaches in depicting the underlying organization of ADHD have relied on the categorical structure represented in the *DSM-IV-TR*. Unlike prior studies, we did not depend on the *DSM-IV-TR* to characterize the underlying structure of ADHD; instead, a dimensional measure was used to characterize the respective classes of ADHD. Studies in both the child and adult literature indicate that most of the common diagnoses may be better represented by a dimensional approach than by categorical constructs (Hudziak, Wadsworth, Heath, & Achenbach, 1999; Kendler et al., 1996; Meehl, 2001). When a categorical structure is imposed on dimensional construct important information can be lost (Ostrander et al., 1998). Therefore, the imperfect convergence between the respective DICA diagnosis and the latent class structure may be partially a reflection of the power restrictions that are associated the categorical imposition associated with the *DSM* nosology. In contrast, our study's reliance on a dimensional measure of psychopathology to characterize the latent classes of may provide a more accurate depiction the how different forms of psychopathology co-occur in children with ADHD (Caron & Rutter, 1991).

### Implications for Research, Policy, and Practice

More than 15 years ago Kendall and Clarkin (1992) asserted that comorbidity is "the premier challenge facing mental health professionals in the 1990s" (p. 833). Yet Jensen (2003) noted that there have been few systematic studies concerning the diagnostic, etiology, and treatment implications associated with overlapping psychopathology. Our study would suggest that the core symptoms of ADHD seldom occur in isolation. Moreover, there is also emerging evidence that would suggest that comorbidity is associated with a differential response to treatment. For example, the MTA study found that ADHD children with comorbid anxiety were more likely to benefit from a combination of treatments. In fact, the combination of behavioral interventions and psychostimulants achieved the most profound clinical benefit among ADHD children that had both disruptive/behavioral and anxiety disorders (Jensen et al., 2001). Given these findings, one might expect that psychostimulants would achieve a clear-cut treatment response for the classes with the lowest rates of comorbidity (i.e., Mild ADHD and Inattentive-Only classes). Although an effective treatment for approximately half of the children with ADHD may be limited to psychostimulants, a more useful treatment for the remaining

classes of the ADHD may include a combination of behavioral and pharmacological interventions. Of course, identifying the optimal treatment approach for the respective classes of ADHD will need to be tested in future research. Indeed, there is a glaring need for policy and funding initiatives that will promote a better understanding of whether the classification of ADHD based on the co-occurrence of different forms of psychopathology is associated with a differential approach to prevention and treatment (Jensen, 2003).

## REFERENCES

- American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., rev.). Washington, DC: Author.
- American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.
- Angold, A., Costello, E. J., & Erkanli, A. (1999). Comorbidity. *Journal of Child Psychology and Psychiatry*, 40, 57–87.
- Arbuckle, J. L. (1996). Full information estimation in the presence of incomplete data. In G. A. Marcoulides & R. E. Schumacker (Eds.), *Advanced structural equation modeling: Issues and techniques* (pp. 243–277). Mahwah, NJ: Erlbaum.
- Auger, R. W. (2004). The accuracy of teacher reports in the identification of middle school students with depressive symptomatology. *Psychology in the Schools*, 41, 379–389.
- August, G. J., Realmuto, G. M., Crosby, R. D., & MacDonald, A. W., III. (1995). Community-based multiple-gating screening of children at risk for conduct disorder. *Journal of Abnormal Child Psychology*, 23, 521–544.
- Barlow, D. H. (2005). What's new about evidence-based assessment? *Psychological Assessment*, 17, 308–311.
- Baumgaertel, A., Wolraich, M. L., & Dietrich, M. (1995). Comparison of diagnostic criteria for attention-deficit disorders in a German elementary school sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, 34, 629–638.
- Biederman, J., Faraone, S. V., Doyle, A., Krifcher-Lehman, B., Kraus, I., Perrin, J., et al. (1993). Convergence of the child behavior checklist with structured interview-based psychiatric diagnoses of ADHD children with and without comorbidity. *Journal of Child Psychology & Psychiatry*, 34, 1241–1251.
- Biederman, J., Faraone, S. V., Keenan, K., Benjamin, J., Krifcher, B., Moore, C., et al. (1992). Further evidence for the family-genetic risk factors in attention deficit hyperactivity disorder: Patterns of comorbidity in probands and relatives in psychiatrically and pediatrically referred samples. *Archives of General Psychiatry*, 49, 728–738.
- Blackman, G., Ostrander, R., & Herman, K. C. (2005). Children with ADHD and depression: A multisource, multimethod assessment of clinical, social, and academic functioning. *Journal of Attention Disorders*, 8, 195–207.
- Brito, G. N. O., Pinto, R. C. A., & Lins, M. F. C. (1995). A behavioral assessment scale for attention deficit disorder in Brazilian children based on *DSM-III-R* criteria. *Journal of Abnormal Child Psychology*, 23, 509–520.
- Burcussa, S. L., Iacono, W. G., & McGue, M. (2003). Adolescent twins discordant for major depressive disorder: Shared familial liability to externalizing and other internalizing disorders. *Journal of Child Psychology & Psychiatry*, 44, 997–1000.
- Carlson, C. L., & Mann, M. (2002). Sluggish cognitive tempo predicts a different pattern of impairment in the attention deficit hyperactivity disorder, predominantly inattentive type. *Journal of Clinical Child and Adolescent Psychology*, 31, 123–129.
- Caron, C., & Rutter, M. (1991). Comorbidity in child psychopathology: Concepts, issues, and research strategies. *Journal of Child Psychology and Psychiatry*, 32, 1063–1080.
- Cicchetti, D., & Rogosch, F. A. (1996). Equifinality and multifinality in developmental psychopathology. *Development and Psychopathology*, 8, 597–600.
- Crystal, D. S., Ostrander, R., Chen, R. S., & August, G. J. (2001). Multimethod assessment of psychopathology among *DSM-IV* subtypes of children and teacher reports. *Journal of Abnormal Child Psychology*, 29, 189–205.
- Dishion, T. J., French, D., & Patterson, G. R. (2006). The development and ecology of antisocial behavior. In D. Cicchetti & D. Cohen (Eds.), *Developmental psychopathology: Risk, disorder, and adaptation—2nd ed* (Vol. 3, pp. 503–541). New York: Wiley.
- Doyle, A., Ostrander, R., Skare, S., Crosby, R. D., & August, G. J. (1997). Convergent and criterion-related validity of the behavior assessment system for children. *Journal of Clinical Child Psychology*, 26, 276–284.
- DuPaul, G. J. (1991). Parent and teacher ratings of ADHD symptoms: Psychometric properties in a community-based sample. *Journal of Clinical Child Psychology*, 20, 245–253.
- Eiraldi, R. B., Power, T. J., & Nezu, C. M. (1997). Patterns of comorbidity associated with subtypes of attention-deficit hyperactivity disorder among 6- to 12-year-old children. *Journal of the American Academy of Child & Adolescent Psychiatry*, 36, 503–514.
- Faraone, D. M., & Biederman, J. (1997). Do attention deficit hyperactivity disorder and major depression share familiar risk factors? *The Journal of Nervous and Mental Disease*, 185, 533–541.
- Faraone, S. V., Biederman, J., Weber, W., & Russell, R. L. (1998). Psychiatric, neuropsychological, and psychosocial features of *DSM-IV* subtypes of attention-deficit/hyperactivity disorder: Results from a clinically referred sample. *Journal of the American Academy of Child and Adolescent Psychiatry*, 37, 185–194.
- Fergusson, D. M., & Horwood, J. (1995). Predictive validity of categorically and dimensionally scored measures of disruptive childhood behaviors. *Journal of the American Academy of Child Adolescent Psychiatry*, 34, 477–485.
- Fischer, M., Barkley, R. A., Fletcher, K. E., & Smallfish, L. (1993). The stability of dimensions of behavior in ADHD and normal children over an 8-year follow-up. *Journal of Abnormal Child Psychology*, 21, 315–337.
- Gadow, K. D., Drabick, D. A. G., Loney, J., Sprafkin, J., Salisbury, H., Azizian, A., et al. (2004). Comparison of ADHD symptom subtypes as source-specific syndromes. *Journal of Child Psychology and Psychiatry*, 45, 1135–1149.
- Goyette, C. H., Conners, C. K., & Ulrich, R. F. (1978). Normative data on the Revised Conners Parent and Teacher Rating Scales. *Journal of Abnormal Child Psychology*, 6, 221–236.
- Herman, K. C., & Ostrander, R. (in press). The effects of attention problems on depression: Developmental, academic, and cognitive pathways. *School Psychology Quarterly*.
- Herman, K. C., Ostrander, R., Walkup, J. T., Silva, S. G., & Marsh, J. S. (2007). Empirically-derived subtypes of adolescent depression: Latent profile analysis of co-occurring symptoms in the treatment for adolescents with depression study (TADS). *Journal of Consulting and Clinical Psychology*, 75, 716–728.
- Holland, M. L., Gimpel, G. A., & Merrell, K. W. (1998). Innovations in assessing ADHD: Development, psychometric properties, and factor structure of the ADHD Symptoms Rating Scale (ADHD-SRS). *Journal of Psychopathology and Behavioral Assessment*, 20, 307–333.

- Hollingshead, A. B. (1975). *Four factor index of social status*. New Haven, CT: Yale University Department of Sociology.
- Holmbeck, G. N., Li, S. T., Schurman, J. V., Friedman, D., & Coakley, R. M. (2002). Collecting and managing multisource and multimethod data in studies of pediatric populations. *Journal of Pediatric Psychology*, 27, 5–18.
- Hudziak, J. J., Wadsworth, M. E., Heath, A. C., & Achenbach, T. M. (1999). Latent class analysis of child behavior checklist attention problems. *Journal of the American Academy of Child & Adolescent Psychiatry*, 38, 985–991.
- Jensen, P. S. (2003). Comorbidity and child psychopathology: Recommendations for the next decade. *Journal of Abnormal Child Psychology*, 31, 293–300.
- Jensen, P. S., Hinshaw, S. P., Kraemer, H. C., Lenora, N., Newcorn, J. H., Abikoff, H. B., et al. (2001). ADHD comorbidity findings from the MTA Study: Comparing comorbid subgroups. *Journal of the American Academy of Child and Adolescent Psychiatry*, 40, 147–158.
- Jensen, P. S., Martin, D., & Cantwell, D. P. (1997). Comorbidity in ADHD: Implications for research, practice, and DSM–V. *Journal of the American Academy of Child and Adolescent Psychiatry*, 36, 1065.
- Jensen, P. S., Rubio-Stipec, M., Canino, G., Bird, H. R., Dulcan, M. K., Schwab-Stone, M. E., et al. (1999). Parent and child contributions to diagnosis of mental disorder: Are both informants always necessary?. *Journal of the American Academy of Child and Adolescent Psychiatry*, 38, 1569–1579.
- Kendall, P. C., & Clarkin, J. F. (1992). Introduction to special section: Comorbidity and treatment implications. *Journal of Consulting and Clinical Psychology*, 60, 833–834.
- Kendler, K. S., Eaves, L. J., Walters, E. E., Neale, M. C., Heath, A. C., Kessler, R. C., et al. (1996). The identification and validation of distinct depressive syndromes in a population-based sample of female twins. *Archives of General Psychiatry*, 53, 391–399.
- Kline, D. N., & Douger, L. R. (2005). Toward guidelines for evidence based assessment of depression in children and adolescence. *Journal of Clinical Child and Adolescent Psychology*, 34, 412–432.
- Kovacs, M. (1992). *Children's Depression Inventory (CDI) manual*. North Tonawanda, NY: MHS.
- Lahey, B. B., Applegate, B., McBurnett, K., Biederman, J., Greenhill, L., Hynd, G. W., et al. (1994). DSM–IV field trials for attention-deficit hyperactivity disorder in children and adolescents. *American Journal of Psychiatry*, 151, 1673–1685.
- Lahey, B. B., Pelham, W. E., Schaughency, E. A., Atkins, M. S., Murphy, H. A., Hynd, G. W., et al. (1988). Dimensions and types of attention-deficit disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, 27, 330–335.
- Leavy, F., Hay, D. A., McStephen, M., Wood, C., & Waldman I. (1997). Attention-deficit hyperactivity disorder: A category or a continuum? Genetic analysis of a large-scale twin study. *Journal of the American Academy of Child Adolescent Psychiatry*, 36, 737–744.
- Little, R. J. (1995). Modeling the dropout mechanism in repeated-measures studies. *Journal of the American Statistical Association*, 90, 1112–1121.
- Lo, Y., Mendall, N. R., & Rubin, D. B. (2001). Testing the number of components in a normal mixture. *Biometrika*, 88, 767–778.
- Loeber, R., Green, S. M., Lahey, B. B., & Stouthamer-Loeber, M. (1989). Optimal informants on childhood disruptive behaviors. *Development and Psychopathology*, 1, 317–337.
- Loeber, R., & Keenan, K. (1994). Interaction between conduct disorder and its comorbid conditions: Effects of age and gender. *Clinical Psychology Review*, 14, 497–523.
- McCutcheon, A. (1987). *Latent class analysis*. Beverly Hills, CA: Sage.
- Meehl, P. E. (2001). Comorbidity and taxometrics. *Clinical Psychology: Science and Practice*, 8, 507–519.
- Moffitt, T. E. (1990). Juvenile delinquency and attention deficit disorder: Boys' developmental trajectories from age 3 to age 15. *Child Development*, 61, 893–910.
- Muthén, B., & Shedden, K. (1999). Finite mixture modeling with mixture outcomes using the EM algorithm. *Biometrics*, 6, 463–469.
- Muthén, L., & Muthén, B. (2004). *MPlus user's guide*. Los Angeles, CA: Muthén & Muthén.
- Neuman, R. J., Heath, A., Reich, W., Bucholz, K. K., Madden, P. A. F., Sun, L., et al. (2001). Latent class analysis of ADHD and comorbid symptoms in a population sample of adolescent female twins. *Journal of Child Psychology and Psychiatry*, 42, 933–942.
- Neuman, R. J., Sitdhiraksa, N., Reich, W., Ji, TH-C., Joyner, C. A., Sun, L., et al. (2005). Estimation of prevalence of DSM–IV and latent class ADHD subtypes in a population based sample of child and adolescent twins. *Twin Research and Human Genetics*, 8, 392–401.
- Nylund, K., Muthén, B., & Asparouhov, T. (2006). *Deciding on the number of classes in latent class analysis*. Unpublished manuscript.
- Ostrander, R., Crystal, D., & August, G. J. (2006). Attention Deficit-Hyperactivity Disorder, depression, and self- and other-assessments of social competence: A developmental study. *Journal of Abnormal Child Psychology*, 34, 772–786.
- Ostrander, R., & Herman, K. C. (2006). Potential cognitive, parenting, and developmental mediators of the relationship between ADHD and depression. *Journal of Consulting and Clinical Psychology*, 74, 89–98.
- Ostrander, R., Weinfurt, K. P., Yarnold, P. R., & August, G. J. (1998). Diagnosing attention deficit disorders with the behavioral assessment system for children and the child behavior checklist: Test and construct validity analyses using optional discriminant classification trees. *Journal of Consulting and Clinical Psychology*, 66, 1998.
- Pelham, W. E., Fabiano, G. A., & Massetti, G. M. (2005). Evidence-based assessment of attention deficit hyperactivity disorder in children and adolescents. *Journal of Clinical Child and Adolescent Psychology*, 34, 449–476.
- Pillow, D. R., Pelham, W. E. Jr., Hoza, D., Molina-Brooke, S. G., & Stultz, C. H. (1998). Confirmatory factor analyses examining attention deficit hyperactivity disorder symptoms and other childhood disruptive behaviors. *Journal of Abnormal Child Psychology*, 26, 293–309.
- Reich, W., Shayla, J. J., & Taibelson, C. (1992). *The Diagnostic Interview for Children and Adolescents-Revised (DICA-R)*. St. Louis, MO: Washington University Press.
- Reynolds, C. R., & Kamphaus, R. W. (1992). *Behavioral Assessment System for Children manual*. Circle Pines, MN: American Guidance Service.
- Reynolds, C. R., & Richmond, B. O. (1985). *Revised Children's Manifest Anxiety Scale manual*. Los Angeles, CA: Western Psychological Services.
- Ruscio, J., & Ruscio, A. M. (2004). Clarifying boundary issues in psychopathology: The role of taxometrics in a comprehensive program of structural research. *Journal of Abnormal Psychology*, 113, 24–38.
- Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, 7, 147–177.
- Schwartz, G. (1978). Estimating the dimensions of a model. *The Annals of Statistics*, 6, 461–464.
- Sclove, L. S. (1987). Application of a model-selection criteria to some problems in multivariate analysis. *Psychometrika*, 52, 333–343.
- Silverman, W. K., & Ollendick, T. H. (2005). Evidence-based assessment of anxiety and its disorders in children and adolescents. *Journal of Clinical Child and Adolescent Psychology*, 34, 380–411.

- Thapar, A., Harrington, R., & McGuffin, P. (2001). Examining the comorbidity of ADHD-related behaviours and conduct problems using a twin study design. *British Journal of Psychiatry*, 179, 222–229.
- Todd, R. D. (2000). Genetics of childhood disorders: XXI. ADHD, Part 5: A behavioral genetic perspective. *Journal of the American Academy of Child and Adolescent Psychiatry*, 39, 1571–1573.
- Volk, H. E., Neuman, R. J., & Todd, R. D. (2005). A systematic evaluation of ADHD and comorbid psychopathology in a population-based twin sample. *Journal of the American Academy of Child Adolescent Psychiatry*, 44, 768–775.
- Walrath, C. M., Petras, H., Mandell, D. S., Stephens, R. L., Holden, E. W., & Leaf, P. J. (2004). Gender differences in patterns of risk factors among children receiving mental health services: Latent class analysis. *Journal of Behavioral Health Services & Research*, 31, 297–311.
- World Health Organization. (1993). *ICD-10 Classification of mental and behavioural disorders: Diagnostic research criteria*. Geneva, Switzerland: World Health Organization.
- Youngstrom, E., Meyers, O., Demeter, C., Youngstrom, J., Morello, L., Piiparinen, R., et al. (2005). Comparing diagnostic checklists for pediatric bipolar disorder in academic and community mental health settings. *Bipolar Disorders*, 7, 507–517.